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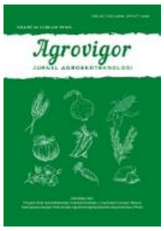

Article

Yield Evaluation of Hybrid Maize Candidates with High Productivity and Drought Tolerance

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ABSTRACT

One solution to solve the problem of low maize productivity in dry land is to develop superior maize varieties with high production characteristics and resistance to drought stress. This study aims to evaluate the characteristics of 10 hybrid maize candidates with high production characteristics and resistance to drought stress. The research used a Randomized Complete Block Design (RCBD) with 13 genotypes (10 hybrid maize candidates, three comparison varieties (Jakaring, Pioneer-X, and Bisi-X) as treatments and was repeated three times, so that there were 39 experimental units. Drought stress research follows the CIMMYT method. The observation parameters in this study were plant height, stem diameter, number of leaves, leaf length, leaf area, ear height, days of 50% tasseling, days to 50% silking, harvest age, number of kernel rows, weight of cob with husk, ear length, ear diameter, kernel width, kernel length, kernel thickness, 1000-kernel weight, and production per hectare. The results of the variance analysis showed that several genotypes tested had a significant effect on the characters of plant height, stem diameter, number of leaves, leaf length, leaf area, ear height, days of 50% tasseling, days to 50% silking, harvest age, number of kernel rows, weight of cob with husk, ear length, ear diameter, kernel width, kernel thickness, 1000-kernel weight, and production per hectare. The value of heritability in the broad sense of candidate maize for all evaluated characters ranged from 0.00-97.64. The character of production per hectare significantly correlates with the ear length and ear diameter, with respective correlation coefficient values of 0.36 and 0.56. The character of the ear height had a significant negative correlation with the production per hectare character, with a correlation coefficient value of -0.39. The selected genotypes in releasing hybrid varieties were G1, G2, G3, G4, and G6.

INTRODUCTION

Maize, along with rice and soybeans, is an important food commodity in Indonesia. It serves as human food, animal feed, and industrial raw materials. Indonesia is one of the largest maize producers in Southeast Asia. In 2024, the area of maize plantations in Indonesia will be 2.47 million hectares with a production of 19.98 million tons (FAOSTAT, 2025). However, maize productivity in Indonesia (8.08 tons per hectare) is still below the average maize productivity in Southeast Asia (8.14 tons per hectare) (FAOSTAT, 2025). One of the areas contributing to low maize production in Indonesia is Madura Island. The average maize productivity on Madura Island is 2.15 tons per hectare (Amzeri, 2018). The cause of the low productivity of maize on Madura Island is due to (1) the land for planting maize on Madura Island is dominated by dry land (less fertile), and (2) the lack of superior maize varieties that are suitable for the conditions on Madura Island (Amzeri et al., 2018).

One solution to overcome the low productivity of maize on Madura Island is to develop superior maize varieties with high production characteristics and that are resistant to drought stress (Amzeri, 2017). Characterization based on morphological and molecular characteristics of maize germplasm has been carried out, producing four lines with high production characteristics and resistant to drought stress (Amzeri et al., 2022). The assembly of hybrid maize varieties using potential ancestors through the diallel crossing method produced nine hybrid varieties with high production and resistance to drought stress (Amzeri et al., 2024). In addition, the hybrid maize variety assemblage was carried out using the line x tester method, producing four hybrid maize varieties with high production characteristics and resistance to drought stress (Amzeri et al., 2025).

The next step for releasing superior maize varieties is to conduct several tests to determine the potential and stability of candidate varieties. Several stages must be carried out before releasing a variety, including a Preliminary Test (1 test location), an Advanced Test (3 Test locations), and a Multi-location Test (8 test locations for 2 seasons). The Preliminary Test and Advanced Test results will be used as research material in the Multilocation Test. The Ministry of Agriculture uses the results of the Multilocation Test to issue release certificates for high-yielding and drought-tolerant hybrid maize varieties. This study aims to evaluate the characteristics of 10 hybrid maize candidates with high production characteristics and resistance to drought stress.

MATERIALS AND METHODS

Plant Materials and Research Implementation

The research was conducted in August–December 2024. The research was conducted in Pasean District, Pamekasan Regency, Madura (altitude 50 m above sea level, low C-organic content, pH = 6.8, and Mediterranean red soil type). The research used a Randomized Complete Block Design (RCBD) with 13 genotypes (10 hybrid maize candidates, three comparison varieties (Jakaring, Pioneer-X, and Bisi-X) as treatments and was repeated three times, so that there were 39 experimental units. Each genotype was planted in a 1 x 10 m plot with a spacing of 70 x 20 cm. Drought stress research follows the CIMMYT method (Weber et al., 2012), namely, drought stress takes place when the plants are 50 days after planting (DAP) until harvest but provides irrigation with field capacity from 0 to 40 DAP with intervals of every 10 days. Fertilization is carried out in three stages, namely when the plants are 7 DAP (200 kg/ha SP-36, 100 kg/ha Urea and 50 kg/ha KCl), 25 DAP (100 kg/ha Urea and 50 kg/ha KCl, and 40 DAP (100 kg/ha Urea and 50 kg/ha KCl).

Data Collection and Analysis

The observation parameters in this study were plant height, stem diameter, number of leaves, leaf length, leaf area, ear height, days of 50% tasseling, days to 50% silking, harvest age, number of kernel rows, weight of cob with husk, ear length, ear diameter, kernel width, kernel length, kernel thickness, 1000-kernel weight, and production per hectare. At that time, the moisture content of the seeds usually reaches less than 30%. Observations of maize grain yield were carried out on all plant samples for each experimental unit and converted into maize grain yield per hectare at a water content of 15% using the following formula:

$$Y = \frac{10000}{HA} x \frac{100 - MC}{100 - 15} xGW$$

where: Y : Grain yield (kg/ha); HA : Harvested area per plot (m^2); MC : Moisture content at harvest time (%); GW : Harvested grain weight per plot (kg).

Quantitative character data was analyzed using the F test. If there is a significant effect, continue with the Honestly Significant Difference (HSD) Test ($p<0.05$) using STAR 2.01 software. Estimation of environmental variance, genetic variance, phenotypic variance, and broad heritability (h^2_{bs}) were calculated based on the formula (Hallauer et al., 2010).

$$h^2_{bs} = \frac{\sigma^2_g}{\sigma^2_p}$$

where: h^2_{bs} = broad heritability; σ^2_g = genetic variance; σ^2_p = phenotypic variance

Pearson correlation coefficient analysis is calculated based on the formula (Walpole, 1982).

$$r = \frac{n\sum_{i=I}^{n} xiyi - (\sum_{i=I}^{n} xi)(\sum_{i=I}^{n} yi)}{\sqrt{[n\sum_{i=I}^{n} xi^2 - (\sum_{i=I}^{n} Xi)^2][n\sum_{i=I}^{n} yi^2 - (\sum_{i=I}^{n} yi)^2]}}$$

Where: r = correlation value between variables x and y; n = number of observations; xi = the value of variable x in plant to i; and yi = the value of variable y in plant to i.

RESULTS AND DISCUSSION

The results of the recapitulation of variance analysis on various characters show that several genotypes tested have a significant effect on the characters of plant height, stem diameter, number of leaves, leaf length, leaf area, ear height, days of 50% tasseling, days to 50% silking, harvest age, number of kernel rows, weight of cob with husk, ear length, ear diameter, kernel width, kernel thickness, 1000-kernel weight, and production per hectare. The kernel length character did not significantly affect the variance analysis test (Table 1).

Plant Height, Stem Diameter, Number of Leaves, Leaf Length, Leaf Area, and Ear Height

Observations of plant height, stem diameter, number of leaves, leaf length, leaf area, and ear height are carried out when the plant enters the generative phase. In the plant height character, G6 hybrid maize had the shortest plant height (212.55 cm) compared to other hybrid maize and three comparison varieties (Jakaring, Pioneer-X, and Bisi-X). G1 hybrid maize had the highest plant height (265.57 cm) compared to other hybrid maize and three comparison varieties. In the stem diameter character, G10 hybrid maize had the largest diameter (2.32 cm) compared to other hybrid maize and three comparison varieties. G5 hybrid maize had the smallest diameter (1.87 cm) compared to other hybrid maize and three comparison varieties. Furthermore, the G9 hybrid maize had the most leaves (14.97) compared to other hybrid maize and three comparison varieties. The G6 hybrid maize had the fewest leaves (12.20) compared to other hybrid maize and three comparison varieties.

Table 1. Recapitulation of F test on observed characters

Character	Mean Squares	Coefficient of Variation (%)
Plant height	775.86**	2.19
Stem diameter	0.04**	3.67
Number of leaves	2.68**	2.79
Leaf length	72.18**	2.41
Leaf area	1.46**	4.82
Ear height	236.93**	6.97
Days to 50% tasseling	40.36**	1.97
Days to 50% silking	37.47**	1.73
Harvest age	104.53**	1.01
Number of kernel rows	6.61**	2.85
Weight of cob with husk	1557.54*	9.11
Ear length	5.62**	2.58
Ear diameter	16.92**	4.01
Kernel width	0.74**	3.98
Kernel length	0.24 ns	5.62
Kernel thickness	0.28**	4.48
1000-kernel weight	3059.98**	4.24
Production per hectare	2972418485.39*	9.49

Note : * = significant at 5% level; ** = significant at 1% level; ns = non significant

In the leaf length character, the G1 hybrid maize plant had the longest leaves (96.00 cm) compared to other hybrid maize and one comparison variety (Jakaring). The G5 hybrid maize had the shortest leaf length (83.90 cm) compared to other hybrid maize and three comparison varieties. In the leaf area character, G6 hybrid maize had the largest leaf area (9.76 cm^2) compared to other hybrid maize and three comparison varieties. G2 hybrid maize had the smallest leaf area (7.46 cm^2) compared to other hybrid maize and three comparison varieties. Furthermore, the G7 hybrid maize had the highest ear height (100.95 cm) compared to other hybrid maize and three comparison varieties. G3 hybrid maize had the lowest ear height (68.58 cm) compared to other hybrid ears and three comparison varieties (Table 2).

Days to 50% tasseling, Days to 50% Silking, Harvest Age, Number of Kernel Rows, Weight of Cob with Husk, and Ear Length

The characteristics of days to 50% tasseling, days to 50% silking, harvest age, number of kernel rows, weight of cob with husk, and ear length were significantly different between hybrid maize and comparison varieties. The characteristics of days to 50% tasseling and days to 50% tasseling significantly influence the characteristics of harvest age (Halli et al., 2021; (Yigermal et al., 2024). In the days to 50% tasseling character, G3 hybrid maize had the shortest age compared to other hybrid maize and three comparison varieties. G10 hybrid maize had the longest days to 50% tasseling compared to other hybrid maize and one comparison variety (Pioneer-X). In the days to 50% silking character, G3 hybrid maize had the shortest age compared to other hybrid maize and three comparison varieties. The G9 and G10 hybrid maize have the longest days to 50% silking compared to other hybrid maize and one comparison variety (Pioneer-X). Furthermore, the harvest age of G3 and G5 hybrid maize had the shortest harvest age compared to other hybrid maize and three comparison varieties. The G9 and G10 hybrid maize have the longest harvest period compared to other hybrid maize, but are shorter than the three comparison.

In the number of kernel rows, G2 hybrid maize had the largest number of kernel rows compared to other hybrid maize and three comparison varieties. The G6 hybrid maize had the fewest number of kernel rows compared to other hybrid maize and the two comparison varieties (Jakaring and Pioneer-X). In the weight of cob with husk, the G2 hybrid maize had the heaviest weight of the cob with husk compared to other hybrid maize and two comparison varieties (Jakaring and Bisi-X). The G8 hybrid maize had the lightest weight of cob with husk compared to other hybrid maize and three comparison varieties. Furthermore, the ear length of the G4 hybrid maize had the longest ear length compared to other hybrid maize and three comparison varieties. G5 hybrid maize had the shortest ear length compared to other hybrid maize and three comparison varieties (Table 3).

Ear Diameter, Kernel Width, Kernel Length, Kernel Thickness, 1000-Kernel Weight, and Production per Hectare

The characteristics of ear diameter, kernel width, kernel thickness, 1000-kernel weight, and production per hectare were significantly different between hybrid maize and comparison varieties. However, the kernel length character was not significantly different in all genotypes tested. In the ear diameter character, G3 hybrid maize had the largest ear diameter compared to other hybrid maize and three comparison varieties. G8 hybrid maize had the smallest ear diameter compared to other hybrid maize and two comparison varieties (Jakaring and Pioneer-X). In the kernel width character, G1 hybrid maize had the largest kernel width compared to other hybrid maize and three comparison varieties. G2 hybrid maize had the smallest kernel width compared to other hybrid maize and three comparison varieties.

In the kernel thickness character, G8 hybrid maize had the greatest kernel thickness compared to other hybrid maize and three comparison varieties. G9 hybrid maize had the smallest kernel thickness compared to other hybrid maize and three comparison varieties. In the 1000-kernel weight character, G10 hybrid maize had the heaviest 1000-kernel weight compared to other hybrid maize but is lighter compared to the three comparison varieties. G5 hybrid maize had the lightest 1000-kernel weight compared to other hybrids and three comparison varieties. Furthermore, G2 hybrid maize had the largest production per hectare compared to other hybrid maize and three comparison varieties. G7 hybrid maize had the smallest production per hectare compared to other hybrid maize and three comparison varieties (Table 4).

Table 2. Characteristics of plant height, stem diameter, number of leaves, leaf length, leaf area, and ear height of 10 hybrid maize candidates with three comparison varieties

Genotype	Plant Hight (cm)	Stem Diameter (cm)	Number of Leaves	Leaf Lenght (cm)	Leaf Area (cm²)	Ear Height (cm)
G1	265.57 a	2.18 ab	13.13 cde	96.00 abc	8.15 bcd	93.33 abc
G2	221.77 ef	2.13 ab	13.47 bcd	92.07 bcde	7.46 d	75.82 cd
G3	216.71 ef	2.15 ab	12.25 e	86.33 ef	8.20 bcd	68.58 d
G4	217.80 ef	2.10 abc	13.90 abcd	92.87 bcde	9.30 ab	88.67 abc
G5	216.83 ef	1.87 c	13.10 cde	83.90 f	8.31 bcd	76.70 cd
G6	212.55 f	2.26 ab	12.20 e	90.33 bcdef	9.76 a	77.85 bcd
G7	241.47 bc	2.13 ab	14.50 ab	86.30 ef	8.32 bcd	100.95 a
G8	237.37 cd	2.24 ab	14.93 a	89.40 cdef	9.17 abc	85.72 abcd
G9	230.66 cde	2.21 ab	14.97 a	95.39 abc	8.04 cd	88.21 abc
G10	239.50 cd	2.32 a	14.56 ab	93.60 bcd	9.58 a	80.90 bcd
G11	226.12 def	2.11 ab	12.83 de	87.67 def	8.56 abcd	86.97 abc
G12	256.63 ab	2.29 a	13.17 cde	100.77 a	9.40 ab	82.78 bcd
G13	228.57 cde	2.04 bc	14.07 abc	96.90 ab	8.85 abc	95.05 ab

Note: The numbers followed by the same letter in the same column are not significantly different according to the 5% HSD test

Table 3. Characteristics of days to 50% tasseling, days to 50% silking, harvest age, number of kernel rows, weight of cob with husk, and ear length of 10 hybrid maize candidates with three comparison varieties

Genotype	Days to 50% tasseling (DAP)	Days to 50% silking (DAP)	Harvest age (DAP)	Number of kernel rows	Weight of cob with husk (g)	Ear length (cm)
G1	42.33 de	45.00 ef	87.00 d	15.78 bcd	235.00 abc	19.25 abc
G2	44.33 cd	47.33 cde	87.67 cd	17.67 a	246.47 ab	18.18 bcdef
G3	40.67 e	43.67 f	86.67 d	16.45 abc	237.13 abc	18.74 abcde
G4	43.67 d	46.67 cde	87.00 d	15.44 cde	228.57 abc	20.09 a
G5	42.33 de	45.33 ef	86.67 d	16.89 ab	188.68 bc	15.10 g
G6	43.00 de	45.33 ef	87.67 cd	14.00 f	217.33 abc	17.90 cdef
G7	43.33 d	46.33 de	87.67 cd	15.00 def	193.24 abc	17.32 ef
G8	44.00 cd	46.33 de	87.67 cd	16.89 ab	185.23 c	16.86 f
G9	46.33 bc	49.00 bc	90.00 c	14.22 ef	230.70 abc	19.07 abcd
G10	47.00 b	49.00 bc	90.00 c	15.55 cd	235.30 abc	19.37 ab
G11	48.33 b	51.33 b	100.00 b	15.22 cdef	219.81 abc	19.55 ab
G12	46.33 bc	48.67 cd	99.3 b	14.67 def	250.94 a	19.34 ab
G13	55.00 a	57.33 a	103.33 a	12.00 g	191.73 abc	17.67 def

Note: DAP = days after planting; The numbers followed by the same letter in the same column are not significantly different according to the 5% HSD test.

Heritability

Heritability is an important genetic parameter in plant breeding programs, used to determine the appropriate genotypes to be developed for variety assembly (Yadesa et al., 2022). Heritability value describes the proportion of a character's phenotypic variability that is controlled by genetic factors compared to environmental factors (Schmidt, 2019) (Priyanto et al., 2023). Heritability describes how much a character is inherited from one generation to the next (Yadesa, 2022) and how much of a role genetic factors play compared to environmental influences on variation in that character (Rabou, 2021). Heritability value in the broad sense of candidate maize for all evaluated characters ranged from 0.00 to 97.64 (Table 5). Based on heritability criteria, the characters of hybrid maize candidates have low to high heritability. Characters that have high heritability in the broad sense values are plant height, stem diameter, number of leaves, leaf length, leaf area, ear height, days to 50% tasseling, days to 50% silking, harvest age, Number of kernel rows, ear length, ear diameter, kernel width, kernel thickness and 1000-kernel weight. Characters with moderate heritability in the broad sense values were the weight of cobs with husks and production per hectare. The character with low heritability in the broad sense value was kernel length.

Table 4. Characteristics of ear diameter, kernel width, kernel length, kernel thickness, 1000-kernel weight, and production per hectare of 10 hybrid maize candidates with three comparison varieties.

Genotype	Ear diameter (cm)	Kernel width (mm)	Kernel length (mm)	Kernel thickness (mm)	1000-kernel weight (g)	Production per hecatare (kg)
G1	44.27 ab	8.93 a	8.31	4.79 ab	317.33 cd	10825.16 ab
G2	43.40 abc	7.46 d	9.15	4.00 cd	315.00 cd	11460.07 a
G3	46.95 a	7.83 bcd	8.89	4.38 abcd	303.00 cd	11420.38 a
G4	42.38 abc	7.65 cd	9.12	4.44 abcd	307.67 cd	10198.19 ab
G5	46.12 a	7.75 bcd	9.15	4.00 cd	284.33 d	9404.56 ab
G6	40.39 bc	8.06 abcd	8.79	4.23 bcd	311.67 cd	10975.95 a
G7	39.05 c	7.63 cd	9.43	4.51 abc	307.67 cd	8031.57 b
G8	40.35 bc	8.41 abcd	9.10	4.85 a	328.67 bc	9325.19 ab
G9	40.42 bc	8.52 abc	9.29	3.93 d	328.33 bc	9880.73 ab
G10	42.45 abc	8.36 abcd	9.15	4.36 abcd	332.33 bc	9936.89 ab
G11	42.74 abc	7.86 bcd	9.03	4.62 ab	390.67 a	10158.51 ab
G12	43.11 abc	8.67 ab	9.34	4.23 bcd	383.00 a	10817.22 ab
G13	40.26 bc	8.83 a	9.00	4.04 cd	365.00 ab	9079.17 ab

Note: The numbers followed by the same letter in the same column are not significantly different according to the 5% HSD test.

Table 5. Values of genetic variance, environmental variance, phenotypic variance, and heritability.

Character	$\sigma^2 g$	$\sigma^2 e$	$\sigma^2 p$	h^2_{bs}
Plant height	250.00	25.85	275.85	90.63 (high)
Stem diameter	0.01	0.01	0.02	66.67 (high)
Number of leaves	0.85	0.14	0.99	85.45 (high)
Leaf length	22.43	4.89	27.32	82.10 (high)
Leaf area	0.43	0.18	0.60	70.86 (high)
Ear height	67.35	34.87	102.22	65.89 (high)
Days to 50% tasseling	13.19	0.79	13.98	94.33 (high)
Days to 50% silking	12.26	0.69	12.95	94.70 (high)
Harvest age	34.57	0.84	35.40	97.64 (high)
Number of kernel rows	2.14	0.19	2.33	91.77 (high)
Weight of cob with husk	385.18	401.98	787.17	48.93 (moderate)
Ear length	1.80	0.23	2.02	88.88 (high)
Ear diameter	4.67	2.92	7.58	61.55 (high)
Kernel width	0.21	0.11	0.32	66.70 (high)
Kernel length	0.00	0.26	0.25	0.00 (low)
Kernel thickness	0.08	0.04	0.12	67.52 (high)
1000-kernel weight	955.14	194.56	1149.70	83.08 (high)
Production per hectare	683896540.89	920728862.72	1604625403.61	42.62 (moderate)

Note: $\sigma^2 g$: genetic variance; $\sigma^2 e$: environmental variance; $\sigma^2 p$: phenotypic variance; h^2_{bs}: heritability in the broad sense; heritability criteria: high ($h^2_{bs} \geq 0.5$), moderate ($0.2<h^2_{bs}<0,5$), low ($h^2_{bs} \leq 0.2$)

Table 6. The linear correlation coefficient between characters in the maize genotypes tested.

	PH	SD	NL	LL	LA	EH	D50%T	D50%S	HA	NKR	WCH	EL	ED	KW	KL	KT	1000-KW	PPH
PH	1,00																	
SD	0,31*	1,00																
NL	0,59	0.18	1,00															
LL	0.59*	0.42*	0.29	1,00														
LA	0,16	0.45*	0.14	0.41*	1,00													
EH	0.41*	-0.02	0.47*	0.29	0.11	1,00												
D50%T	0.06	0.0001	0.28	0.36**	0.14	0.34**	1,00											
D50%S	0.03	-0.05	0.28	0.35	0.09	0.34**	0.98	1,00										
HA	0.18	0.02	0.01	0.40	0.20	0.25	0.85	0.86	1,00									
NKR	-0.09	-0.15	-0.09	-0.38**	-0.32**	-0.45*	-0.67	-0.66	-0.63	1,00								
WCH	0.18	0.30	-0.21	0.39**	0.06	-0.18	-0.13	-0.14	0.0013	0.15	1,00							
EL	0.23	0.45*	-0.01	0.43*	0.15	0.05	0.14	0.14	0.22	-0.17	0.18	1,00						
ED	-0.011	-0.25	-0.43*	-0.03	-0.09	-0.37**	-0.39**	-0.36**	-0.19	0.47*	-0.08**	-0.03	1,00					
KW	0.57*	0.25	0.24	0.54*	0.27	0.35**	0.36**	0.32**	0.37**	-0.46*	0.02	0.14	-0.06	1,00				
KL	0.03	-0.10	0.33**	0.18	0.06	0.29	0.04	0.06	0.08	-0.03	-0.26	-0.07	0.007	0.05	1,00			
KT	0.31	0.19	0.0084	-0.23	0.04	0.12	-0.24	-0.26	-0.17	0.23	1,00	0.18	-0.08	0.02	-0.26	1,00		
1000-KW	0.26	0.16	-0.04	0.29	0.12	0.24	0.65	0.64	0.81	-0.40**	0.07	0.38**	-0.15	0.38**	0.125	0.07	1,00	
PPH	-0.05	0.18	-0.47	0.18	0.04	-0.39**	-0.26	-0.26	-0.10	0.25	-0.11	0.36**	0.52*	-0.01	-0.06	-0.11	0.12	1,00

Note: * = significant at 5% level; ** = significant at 1% level; PH = plant height; SD = stem diameter; NL = number of leaves; LL = leaf length; LA = leaf area; EH = ear height; D 50%T = days to 50% tasseling; D50%S = days to 50% silking; HA = harvest age; NKR = number of kernel rows; WCH = weight of cob with husk; EL = ear length; ED = ear diameter; KW = kernel width; KL = kernel length; KT = kernel thickness; 1000-KW = 1000-kernel weight; PPH = production per hectare.

Correlation between Quantitative Characters

Assessing the correlation between quantitative characters in a breeding program is crucial to determining an effective selection strategy (Yeshitila et al., 2023). Correlation between characters provides an overview of the closeness of the relationship between the correlated characters. Characters with a positive correlation indicate that increasing one character will increase another. In contrast, characters with a negative correlation indicate that increasing one character will decrease another (Velho et al., 2017) (Abikkumar et al., 2023). Correlation information between characters is beneficial in indirectly selecting characters with economic value (Rahman, 2020). Indirect selection aims to make the selection process more efficient in terms of manpower, time, and costs. One of the characters that has economic value in this study is production per hectare. Selection on other characters with negative or positive correlation values is beneficial for indirect selection on the character of production per hectare.

Table 6 shows that the production per hectare character significantly correlated with the ear length and ear diameter, with respective correlation coefficient values of 0.36 and 0.56. Furthermore, the character of the ear height had a real negative correlation with the production per hectare character, with a correlation coefficient value of -0.39. Based on these results, indirect selection can be carried out on three characters: ear length, ear diameter, and ear height.

Determination of Hybrid Maize Candidates in Variety Release

The character of production per hectare is the main indicator in determining hybrid maize candidates for releasing hybrid varieties because it directly reflects the potential yield that can be achieved in the field. In addition, the harvest age character is an important supporting character. Genotypes with early maturity characters can better survive drought conditions by completing their life cycle earlier and avoiding the critical phase when maximum water stress occurs (Amjid & Üstün, 2025). In addition, the selection of hybrid maize candidates to be released as superior varieties is not only based on agronomic performance, but also considers genetic parameters, namely heritability values and correlation coefficients between characters. The heritability value provides an idea of how much genetic factors influence the diversity of observed characters (Sinare et al., 2024). A character with high heritability illustrates that the character can be inherited stably and effectively to its offspring (Belay, 2018). Furthermore, the correlation coefficient value between characters is used to determine the relationship between characters that indirectly influence characters that have economic value (Ullah et al., 2018). Integration of heritability values and correlations between characters can help plant breeders determine hybrid maize candidates with high and consistent genetic potential for release as hybrid maize varieties.

Based on the production per hectare character, G1, G2, G3, G4, and G6 had a production per hectare of more than 10 tons per hectare and exceeded three comparison varieties, except for G4, which had a production per hectare lower than one comparison variety (Pioneer-X). The five hybrid maize candidates also have an early maturity because they had a harvest age of less than 95 days (Azrai, 2013). Both parameters (production per hectare and harvest age) had moderate and high heritability, so that these characteristics will be inherited in succession. The negative correlation coefficient between the production per hectare character and harvest age was insignificant (-0.10), so the two characters do not influence each other in displaying their performance.

CONCLUSION

The results of the variance analysis showed that several genotypes tested had a significant effect on the characters of plant height, stem diameter, number of leaves, leaf length, leaf area, ear height, days of 50% tasseling, days to 50% silking, harvest age, number of kernel rows, weight of cob with husk, ear length, ear diameter, kernel width, kernel thickness, 1000-kernel weight, and production per hectare. Heritability value in the broad sense of candidate maize for all evaluated characters ranged from 0.00 to 97.64. The character of production per hectare significantly correlates with the ear length and ear diameter, with respective correlation coefficient values of 0.36 and 0.56. The character of the ear height had a significant negative correlation with the production per hectare character, with a correlation coefficient value of -0.39. The selected genotypes in releasing hybrid varieties were G1, G2, G3, G4, and G6.

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